Final

Third Party Review

Alton Natural Gas LP Brine Storage and Discharge Facility Project

Prepared for: Kwilmu’kw Maw-klusuaqn Negotiation Office

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## List of Appendices

Appendix A List of Documents Provided by Alton Gas to KMKNO
Section 1.0  Introduction

The Kwilmu’kw Maw-klusuaq’n Negotiation Office (KMKNO) retained Conestoga-Rovers & Associates (CRA) to review the Environmental Assessment Registration (EA) report and associated documentation for the proposed Alton Natural Gas LP Brine Storage and Discharge Facility Project (the Project). In this report, CRA focused on the review on the assessment of potential impacts of the proposed Project on fish and fish habitat of the Shubenacadie Estuary (Estuary) and upstream river area.

The purpose of the review is report is to:

- Complete a literature review of existing information for similar operations around the world, specifically, on solution mining, brine discharge requirements and the associated environmental impacts.
- Review the existing information to evaluate the scientific and technical information for completeness and for comparison to documented and validated scientific methods including the interpretation of the information with generally accepted standards of good scientific practice.
- Identify any information gaps and, if warranted, recommendations on how to address the information gaps.

The CRA team completing the documentation review and data gap analysis was selected from a team of environmental professionals that has experience in environmental assessments and aquatic ecology with specific project experience in natural gas storage projects involving brines and brine discharge.

1.1  Project Description

The Alton Natural Gas storage project consists of the development of an underground hydrocarbon storage facility near Alton, Nova Scotia. As outlined in the Environmental Assessment Alton Gas prepared for the Nova Scotia Minister of the Environment, the main aspects of construction involved in the project are: the water intake and diluted brine discharge facilities; laying and connecting the water and brine pipelines; drilling vertical holes to initiate the creation of the salt caverns; and developing the salt caverns.

The water intake facility will take water from the Shubenacadie River which will then be used in the dissolution of the salt bodies under the site. This water will then mix with the dissolved salt from the deposit and be brought back to the surface creating cavern space for the storage of natural gas. This brine will then be stored in a brine pond before being discharged to a mixing channel constructed alongside the Estuary. The brine will be discharged via a diffuser pipe at
the bottom of the channel overtopped by coarse rock berm; this combination is designed to
dilute the brine by an order of magnitude or more before the brine actually reaches the water
column of the mixing channel. From the mixing channel the now diluted brine will then be
released back into the river on a schedule that attempts to conform to the natural salinity
fluctuations that occur in the estuary system.

Once construction of the caverns has been completed natural gas will be injected and
withdrawn to meet market demands within the surrounding area. Through the development of
this project, Alton Gas has prepared and submitted an Environmental Assessment Report in
2007, a report of additional information as requested by Nova Scotia Environment in 2007. An
additional Environmental Assessment for the construction of a natural gas pipeline was
completed in 2013. As of 2015, brine water pipeline and site facility construction has been
completed and drilling at the cavern site has begun.

1.2 Existing Environmental Conditions

The Alton Natural Gas site is located next to the Shubenacadie River, which is part of a very
complex tidal estuary system. This Estuary is the source of water intake for the project as well
as the location for brine discharge. As such, the conditions within the estuary, both
environmental and biological, are of great importance to the project, since any positive or
negative effects of the project will be experienced by the river Estuary system.

As part of the 2007 Environmental Assessment, Martec Ltd. completed a description of the
Shubenacadie River, which is included in the Assessment; Appendix A, “Physical Description of
the Shubenacadie River”. Martec completed a field program in 2006 to establish trends in
salinity, flow, and water elevation throughout the Shubenacadie-Stewiacke river system.
Through this description Alton Gas obtained the majority of their data with regards to this
system’s salinity.

The Shubenacadie River is a tidal bore river in Nova Scotia, Canada. The Estuary experiences
extreme changes in salinity, temperature, water elevation, suspended sediment and river
bottom configuration over very short temporal periods (less than 1-hour). The river meander
length is approximately 50 kilometers from its source at Shubenacadie Grand Lake to its mouth
at Maitland on Cobequid Bay. The river system receives freshwater from a relatively large
watershed area (2600 km²) that includes the Stewiacke River, a tributary to the Shubenacadie
River. The confluence of the Stewiacke and Shubenacadie Rivers is located approximately 22
kilometers upriver of the latter’s mouth. Due to the extreme tidal forcing (> 10 m large tidal
range) from Cobequid Bay, the lower 30 kilometers of the river (Figure 1.0) of both rivers is
tidal. Within this lower reach (tidal) of the river, the brackish water has salinities that can vary
from 0 to 25 ppt over a single tidal cycle (Martec Ltd. 2007).
Due to the variance in salinity experienced in the Shubenacadie – Stewiacke Estuary it is home to diadromous, anadromous and catadromous fish species. It is also home to various invertebrate species. Three species found with the system are classified as being of concern; Atlantic salmon, Striped bass, and Atlantic sturgeon. Atlantic salmon are protected under the Species at Risk act (SARA), striped bass are listed as threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and the Nova Scotia Department of Natural Resources (NSDNR) has red listed the Atlantic Sturgeon. Fish species that are known to spawn in the Estuary or the associated fresh water system include:

- Sea Lamprey
- Atlantic Sturgeon
- Brook Trout
- Atlantic Salmon
- Brown Trout
- Striped bass
- Gaspereau
- Blueback herring
- American shad
- Rainbow smelt
- Stickleback species
- Mummichog
- Atlantic silverside
- Atlantic tomcod
- Chain pickerel
- Yellow perch
- White perch
- American eel

Some benthic organisms present include microalgae, tube dwelling amphipod, *Corophium volutator*, and various worm species. Aquatic mammals which can be present include river otters, mink, harbor seals, and harbor porpoises.

Water intake facilities and brine discharge facilities were designed by Matrix Solutions Inc. for Alton gas and a design summary is included as Appendix B1 of the 2007 Environmental
Assessment The water intake facility will take 11,750 m$^3$/day of water, of which 1750 m$^3$/day will return directly to the river as discharge from the hydrocyclones, which remove most suspended matter. The brine discharge facility will take the brine returned from the caverns and store it in a pre-mixing pond before it is discharged to the mixing channel. The salinity of this brine before mixing is expected to be 260 ppt. No pumping would be require as non-tidal river flow enters the mixing channel and is then discharged during times of higher salinity flood tides.

Section 2.0 Methods

CRA assembled a project team to complete a comprehensive literature review of existing information on the Alton Natural Gas project. The CRA team has carefully reviewed the documents Alton Gas provided to the province to obtained approval of their Environmental Assessments. The team has also reviewed all documents provided to KMKNO by Alton Gas and has created a table which summarizes the contents of all of these documents. (Appendix A) Review of the contents of these documents has led to the conclusions discussed within this report. A number of external documents were also consulted to contextualize the actions taken and decisions made by Alton Gas throughout the process of developing and registering their Environmental Assessment.

Section 3.0 Results

3.1 Overreaching Observations

In general, the EA methods and subsequent data provided by Alton have allowed the Nova Scotia Department of Environment and Labour (NSDEL) to make a decision for the Project to proceed. The following are some general observations on the EA documentation provided:

- The EA submitted for the project was generally completed consistent with the guidelines for NS Environmental Assessment Regulations and provided a logical approach in identifying potential impacts to environment and potential mitigation measures
- The EA submitted for the project was limited to development of the salt cavern for storage of natural gas as well as the brine discharge infrastructure but did not include an evaluation of the construction of a natural gas pipeline from the Maritimes and Northeast pipeline to the storage cavern. A separate EA for the natural gas pipeline was to be submitted to the NSDEL. The splitting of project components into separate EAs is atypical and does not allow for the evaluation of overlapping effects from the proposed project or potential cumulative effects
• Cumulative effects from the proposed project and other on-going projects in the area were not specifically addressed in the EA report but were considered to be negligible as part of subsequent correspondence.

3.2 Scientific and Technical Completeness of Provided Information

Over the course of the planning and approval process, starting in 2007, the project has received extensive review from a variety of government sources, especially DFO. As part of the long-term and on-going consultation, potentially critical environmental issues identified were impacts on fish stocks and fish habitat. Of special concern were potential impacts on three species of concern: Atlantic salmon, Atlantic sturgeon, and Striped bass. However, other species of fish and invertebrate prey species were considered in various background documents. Based on consideration of the project, several potential impacts of the project were noted: potential disruption of upstream migration of anadromous fish by alteration of the river’s bouquet; potential entrainment and impingement of fish associated with water withdrawals; toxicity of brine/estuary water mixtures; and impacts on sediment loads. Other issues considered, and then quickly dismissed, were significant effects on salinity of the Estuary and the thermal regime of the Estuary.

In response to these concerns, the project has taken an interactive and collaborative approach to assessing potential impacts. Thus, potential risks to fish were screened first based on available life history information and on the assumption that very small life forms, such as fertilized eggs (eggs) and very early life stage larvae, would be most sensitive to effects. These very life stages are typically planktonic, which means they are carried around largely by ambient water currents rather than active locomotion. In contrast to the ichthyoplankton, larger larval, juvenile, and adult fish can typically swim fast enough to avoid impingement, entrainment, and plumes of potentially toxic brine mixtures. Given this background, potential effects on many resident fish species could be, and were, dismissed in early stages of this process because those species do not spawn or have vulnerable eggs/larvae near the Site.

In contrast, Striped bass do have eggs/larvae near the Site so this basic screening process focused attention on Striped bass. Striped bass are a species of concern in the Estuary and also an important part of the fishery. These fish are known to spawn upstream in the Stewiak River, and their eggs and developing larvae are subsequently carried down to the Estuary alongside the Site, potentially into harms way. However, the specifics of spawning and life history dynamics of bass in the Estuary were not well known. The Shubenacadie Estuary differs in important respects from other estuaries in which bass spawn, so an early recommendation of regulatory reviewers was that more information on the temporal and spatial distribution of Striped bass eggs needed to be obtained. This recommendation was a specific condition of the Nova Scotia Environment approval.
"A plan to gather baseline information on water temperature and the presence of Atlantic salmon, Striped bass and Atlantic sturgeon eggs and larvae during one spawning season prior to the commencement of solution mining".

Although consideration of life history characteristics indicated the salmon and sturgeon eggs/larvae would not likely be impacted, the directive for further study included these two additional species. Although the rationale for this is not stated, it is likely because these two populations are so precarious that even low levels of uncertainty about potential impacts were considered unacceptable.

In response to this directive/recommendation, a detailed and continuing monitoring program has gathered baseline information of the last 7 years and counting. The physico-chemical information includes not just water temperature but salinity and flow. The sampling of biota has focused on times and locations most pertinent to Striped bass, but the detailed sampling of eggs, fry, and juvenile fish has also sought the presence of salmon and sturgeon. As was predicted by history considerations but also their very small populations, salmon and sturgeon eggs and larvae were apparently never observed in the rather extensive sampling.

This collected information (since 2007) has greatly expanded the knowledge base concerning Striped bass dynamics and to lesser extent, their prey in the Shubenacadie Estuary. Based in part on the last seven years of sampling, it is now well established that this stock is currently as numerous as it has been in decades. At the same time, these detailed studies suggest that the Shubenacadie population is vulnerable. Nova Scotia is at the edge of the habitat range for Striped bass, and the Estuary poses additional significant constraints on bass recruitment.

Although all the factors causing successful or failed recruitment are not well established, very good recruitment probably relies on succession of favorable weather conditions all of which must occur. Thus, weather conditions must sequentially spur good spawning, good retention in the Estuary, and provision of adequate densities and types of prey at appropriate locations and times in bass larval development. Even if all of these propitious event occur in the same year, age zero fish in this northern clime have a very short period in which to grow to a size sufficient to allow over-wintering. Thus, recruitment in the Estuary tends to fail in many years; the currently large population of Striped bass is thought to be due almost entirely to one or two very good year-classes, rather than constant successful recruitment per year. During the intensive sampling of eggs and fry, even though populations of adult fish are high, recruitment has probably been low because all essential conditions have not been optimal.
3.3 Existing Information for Similar Operation

Largely because of the enormous tides, the physico-chemical environment present in the Bay of Fundy and the Shubenacadie River are very unique. The massive tidal force of the bay influences the Shubenacadie River, making the Estuary a somewhat unique environment in a way that has very few analogous environments. As such, a single analogous project was not found in available literature for comparison to the Alton Project. However, aspects of various projects, including biological and environmental chemistry components, can be used for comparison purposes and described in the following paragraphs.

Projects that have similar aspects of brine discharge are various desalination projects which often discharge into near shore tidal environments. Alton Gas’ research and design of the discharge facility has taken into consideration and referenced existing mathematical models of brine desalination such as the work of D.D. Shao’s “Brine discharge into shallow coastal waters with mean and oscillatory tidal currents”.

Numerous papers and studies exist which attempt to determine the effects of salinity changes on fish species. With the introduction of a brine to the area surrounding the project site some species, at various life stages, could be exposed to slight or potentially higher salinity changes near the outfall area. Species found in the Shubenacadie River and associated estuary are regularly exposed to a change in salinity of 0-30 part per thousand (ppt) due to the 30 km tidal influence from the Bay of Fundy. Therefore many of the fish species in the River have to adapt to changes in salinity and may be unaffected by the changes in salinity. A study completed by Hiroi, and McCormick exposed lake trout, brook trout, and Atlantic Salmon directly to 30 ppt salinity waters, and gradually to 10, 20, and 30 ppt waters. Atlantic salmon, which are of concern in the project area, showed a 100% survival rate to both experiments. Brook trout, which are also present, had a 50% survival rate in the direct exposure scenario and 100% in the gradual exposure experiment. This study does not help to understand effects on recruitment or growth but does indicate dramatic increases in salinity are acutely lethal to some salmonid species.

A study from Mississippi State University in collaboration with the University of British Columbia produced a paper titled “Salinity affects on Atlantic Sturgeon”. In this study, juvenile Sturgeon were exposed to waters ranging in salinity from 0-33 ppt. The Sturgeon were identified to have the ability to grow and adapted to salinity changes up to 30 ppt. Salinity concentrations greater than 30 ppt were tolerated by sturgeon but concentrations higher than that inhibited growth. Fish were on average 10 cm shorter and 5 kg smaller (sturgeon can grow up to 370 kg and 4.3 m). The effects on juveniles is important as Atlantic Sturgeon may travel up the Shubenacadie River to spawn thus exposing the juveniles to conditions near the project site.
3.4 Identified Uncertainties and Data Gaps

Major Ion Composition of Brine

The major ion composition of the brine and brine-estuary water mixtures are not apparently known. According to several reports in the provided information, the salt deposits are almost entirely sodium chloride, but analytical data reports of the concentrations of other major ions were not available in the literature reviewed. This is important because although dissolved solids in ocean water are largely sodium chloride, ocean water also includes significant concentrations of other biologically active ions, notably potassium, magnesium, calcium, and sulfate. Aquatic species may, therefore, be impacted by changes in salinity and also by changes in the ionic composition of salinity. We believe this to be a minor datagap. The brine will be diluted by an order of magnitude or more in the mixing channel, so it is unlikely that ionic differences between brine and Estuary water would be biologically meaningful. However, this datagap can be filled easily; the chemical analyses are inexpensive and easily done. Therefore, the ion composition for various mixtures of brine and estuary water should be tested with a range of Estuary water salinities that would be taken in for mixing. Ironically, if ion composition is a critical factor in fish effects, the effects of brine might be most extreme during periods of very low salinity in the Estuare adjacent to the Site and resulting relatively low salinity in the brine/river water mixture. In addition, if there is a potential that salt/brine quality varies from cavern to cavern or within the same cavern, this potential datagap can be easily addressed by chemical analyses suggested above.

Determination of Toxicity of Brine-Estuary Mixture to Fish

Along the same lines, the potential toxicity of the brine/estuary mixture to ambient biota has not been established. At several points in the record, DFO recommends and the proponent agrees that toxicity information for Striped bass will be produced. However, it has not yet been produced. To be most informative, the bioassays should focus on replicating conditions in the mixing channel; i.e., mixing of real brine water with real Estuary water. DFO originally asked for bioassays with all life stages of Striped bass, but most recently asked for bioassays with only smaller life stages, which we believe is appropriate. However, because very small organisms are much less mobile and, because of their size, much quicker to equilibrate with abrupt changes in water quality, potential effects on eggs, larvae, and juveniles are the more important datagaps.

Alteration of the Estuary’s Bouquet and Disruption of Anadromous Fish Spawning

The issue of the brine addition affecting homing of anadromous fish is also a data gap. The potential concern here is based on the fairly well established hypothesis that salmon, and maybe other fish, smell the way back to their natal tributary. This potential effect is discussed but not really addressed in the provided information (and given the small numbers of salmon,
may not be addressable with any sampling). However, this is considered a minor datagap for two reasons. First, the contribution of brine to the bouquet of smells at the mouth of estuary will likely be negligible since the brine will make up such a tiny proportion of the water at the mouth. Second, the science on the importance of olfaction in anadromous fish homing is unsettled. As with many rivers discharging to the Ocean, the bouquet of smells at the mouth of the Shubenacadie Estuary will vary dramatically from time to time depending on the amount of upstream river flow. Thus, recent analyses suggest that salmon use a combination of homing methods – magnetic fields for migration in the ocean to the mouth of the natal stream and, once in natal estuary, olfaction to determine the natal tributary. If this latter theory is true, potential effects on anadromous fish will be non-existent since the brine discharge cannot effect the earth’s magnetic field, and the point where olfaction becomes critically important occurs upstream of the brine discharge.

**Potential Effects of Entrainment and Impingement on Ichthyoplankton**

The issues of entrainment and impingement of ichthyoplankton are data gaps. However, effects of entrainment and impingement for water taken to the caverns is very likely negligible since the volumes of water are also very small. Entrainment of eggs and larvae in the mixing channel could be potentially significant only if both the following are true: 1) a significant number of eggs and larvae are entrained into the mixing channel and 2) the brine-river water mixture is either poorly mixed and/or acutely toxic after mixing in the channel. According to the EA supporting documentation, the mixing channel may entrain about 14% of the eggs and fry, so the potential effects are assumed to be limited even if the brine were toxic. However, this estimate is beset by two antagonistic uncertainties. First, the estimate of 14% of eggs/fry being entrained in the mixing channel pertains to a single ebb flow. However, at lower upstream river discharges, the same group of eggs might pass the site repetitively and, thus, have a potential of being entrained into the mixing channel for each ebb flow. Thus, the estimated 14% chance of being entrained and exposed to brine mixture might significantly underestimate the total potential for entrainment/exposure. Second, the current plan calls for stopping brine discharge during peak spawning times. If this is done, entrainment AND exposure to brine in the mixing channel would be less than 14% of total eggs/fry, albeit only during each ebb flow. As such, to aleviate the datagap associated with point number 1 above, potential entrainment in the mixing channel should be estimated for ichthyoplankton which accounts for the potential repetitive entrainment during repeated ebb flows. The datagap for point number 2 can be addressed with chemical analyses of the brine-estuary mixture and/or fish toxicity studies recommended above.

**Understanding Critical Factors Causing Success or Failure of Striped Bass Recruitment**

The exact factors causing success or failure of Striped bass recruitment is potentially a significant data gap. Despite intensive sampling over now several years, the critical factors
affecting Striped bass recruitment are not fully understood. The now fairly extensive information suggests that total egg released and fertilized may be affected by the weather. Near-term survival of the fertilized eggs and of early larvae is probably largely dependent on subsequent rainfall and runoff. Heavy rains/high runoff soon after spawning presumably carries the fertilized eggs and larvae out of the estuary, where temperatures, salinities, and prey densities are suboptimal. Assuming that fertilized eggs and larvae are not prematurely flushed out of the Estuary, subsequent survival and growth for juvenile bass is presumably a function of prey densities. The densities and distribution of the critical first prey, copepods and then major prey of large fry, mysids, are also a not-well understood combination of dependent of rivers flows and water temperature. Hence, very successful bass recruitment may depend on the simultaneous occurrence of several unrelated weather events, which means that recruitment success is both very sporadic and currently difficult to predict.

The naturally precarious nature of Striped bass recruitment has antagonistic effects on the effectiveness of the long-term monitoring program. Notably, meager recruitment during brining operations is not strong evidence of impacts since recruitment is often poor for other reasons. Without understanding why recruitment failed, it would be difficult to require significant changes to the project or even what those changes should be.

Unfortunately, this datagap cannot be filled easily. Despite almost 7 years of detailed sampling, the scientists still do not fully understand factors controlling recruitment. Nonetheless, filling other datagaps and results of during-project monitoring will reduce the uncertainty associated with this data gap. Thus, for example, a better understanding of brine ionic composition, its potential toxicity, and success of mixing of brine/estuary water in the mixing channel could help dismiss brine discharges as a significant cause of bass mortality. Similarly, the ichthyoplankton will be monitored at several locations during project operation, and these data can also be useful in determining whether the project could cause significant effects.

**Definition and Determination of Peak Spawning Events During Which Brine Discharge Will Be Curtailed**

The current sampling plan suggests that brine discharge will be discontinued during “peak spawning events”. However, it is unclear how “peak spawning events” will be defined and determined effectively. Based on extensive sampling already conducted, it is likely that “peak” will be defined as some threshold of eggs and planktonic larvae per volume of Shubenacadie River water at the Site or flow across the Site per time. The specific values should be provided. A second datagap that should be filled is how this will be effectively determined. The following factors suggest that a major spawning event might be well underway, along with ongoing brine discharge, before it was noticed with the sampling plan. Thus, spawning events can be short-lived, there may be several days interval between samples (planned samples are every 4 to 5 times per week), and there appears to be some lag between sampling and analysis of eggs. This
is probably not a major data gap because major spawning activity by adult fish is apparently obvious, at least during the daytime, and somewhat predictable by water temperature and date. Given this, samples might be taken more often, and with fewer consecutive days without samples, during periods of observed or likely spawning. With appropriate labor, the lag time from sampling to analysis and results can be set to some minimum (e.g., next day or sooner after sampling) to minimize the lag between sample and results.

**Impacts on Atlantic Salmon and Atlantic Sturgeon Are Uncertain**

Given their small, precarious populations, potential impacts on both Atlantic salmon and Atlantic sturgeon will be both difficult to measure and have a very low tolerance. Even impacts on a small numbers of individuals may be too much, although they will be very difficult to discern. As described several places in the reviewed information, Project-related impacts on these two species are quite unlikely because of their life histories and the negligible effects of the project on physio-chemical environment of the Estuary. Nonetheless, a condition imposed for this project was that there be baseline monitoring of eggs and larvae of these two species.

Although monitoring specifically for salmon and sturgeon was not apparently done, a very considerable amount of monitoring of fish eggs and fry in the Estuary was conducted since 2007. At least some of these analyses looked for salmon and sturgeon. Thus, for his Masters thesis, Reesor took over 554 plankton net tow samples between 13 May to 6 November 2008 and 5 May to 28 October 2009. Neither Atlantic salmon nor Atlantic sturgeon were caught during this rather intensive study. These negative results support the conclusion that sensitive eggs and larvae of these two species will not occur in the area affected by the project. There also is some sampling planned to determine whether salmon smolts enter the mixing channel, but CRA could not find any information at all on past or planned sampling for Atlantic Sturgeon.

**The Potential for Sediment Fouling of Rock Berm/Diffuser is Unknown**

The current plan is to discharge the brine to a diffuser pipe buried below a coarse rock berm in the middle of the mixing channel. The combination of the diffuser and flow through the coarse rock berm are estimated to dilute the brine by more than an order of magnitude prior to the brine reaching the water column. An airline will also installed in the berm to add additional mixing if monitoring shows insufficient mixing of brine or “to help flush out sediment.” In view of the very high concentrations of sediments in the Estuary, the potential for sedimentation and blinding of the berm interstices is unknown and could potentially be significant, even with the airline. Blinding of the interstices of the rock pile would greatly reduce mixing of the brine prior to discharge to the channel’s water column. The potential for this to happen is unknown. However, this data gap can potentially be reduced with some sort of modeling prior to construction and ongoing monitoring after construction.
Section 4.0 Conclusions and Recommendations

In accordance with CRA’s scope of work, the literature provided by KMKNO pertaining to the proposed Alton Project was reviewed as well as available information on similar development projects. Based on CRA’s review, the EA registration document was completed in general accordance with NSDEL requirements. A critical part of the approval process was the requirement for a baseline study of the eggs and larvae of the three native species of concern, Atlantic salmon, Atlantic sturgeon, and striped bass. Because striped bass eggs and larvae occur at and near the Site and are most likely to be impacted, these baseline studies focused on eggs/larvae. Subsequent fish stock studies completed for the Shubenacadie Estuary and River provided additional information on the ecosystem to meet DFO requirements. These additional studies were generally completed using defensible scientific methods, and the data obtained used to develop mitigation strategies to minimize potential effects to the environment. However, the paucity of similar salt cavern development projects with brine discharges to estuaries limited the comparative environmental impact evaluation among similar operations.

Although the Project EA and subsequent studies have provided substantial information on the status of selected fish stocks and fish habitat within the Shubenacadie River and Estuary, CRA has identified several potential data gaps specific to the monitoring and evaluation of effects of the project on fish and fish habitat. These potential data gaps and associated recommended additional studies include the following:

- The major ion composition of the brine and brine-estuary water mixture is not known. Recommend collecting undiluted brine water as well as the brine water diluted with estuary water under various saline conditions to characterize the ionic composition of water potentially being discharge to the Estuary.

- The potential toxicity of the brine to ambient biota has not been characterized even though this was a specific comment from DFO as part of the EA review process. Recommend completing bioassays of Striped bass eggs and larvae using diluted brine water (diluted using Estuary water) under various saline conditions to characterize potential toxic effects to fish at early life stages.

- The EA supporting document estimated 14% of Striped bass eggs and fry passing the Site would be entrained in the intake channel. This estimate of entrainment is based primarily on water flows during a single ebb/flow. It does not take into account the potential for eggs and larvae to repetitively pass into the channel during ebb flow conditions resulting in an underestimate of potential entrainment and exposure of eggs and fry to the diluted brine discharge. Recommend that the planned monitoring of eggs and fry entrainment in the channel be conducted to validate the EA predictions using ichthyoplankton which will account for potential for repetitive entrainment.
• The recruitment of Striped bass within the Shubenacadie River and Estuary are not well understood and current factors causing success or failure of this fish species present limitations in its use as an indicator species for assessing potential effects related to the Project. Recommend that the proposed monitoring plan clearly define “peak spawning events” for discontinuing brine discharge and include a contingency to reduce lag times between sampling and analysis of eggs in the river. In addition, the plan needs to detail how natural variances in Striped bass recruitment in the river will be monitored and correlated to evaluate potential negative recruitment effects related to Project activities.

• In view of the very high concentrations of sediments in the Estuary, the potential for sedimentation and blinding of the mixing channel berm interstices is unknown and could potentially be significant, even with the airline. Blinding of the interstices of the rock pile would greatly reduce mixing of the brine prior to discharge to the channel’s water column. The potential for this to happen is unknown. Recommend that modeling prior to construction and ongoing monitoring after construction occur to confirm the issue is not creating unacceptable impacts.

Section 5.0 Study Limitations

CRA was provided data from KMKNO for this review that has been relied upon for the conclusions reached in this report. CRA also used publically available information as referenced in the report that has been relied upon. This report is intended solely for the Client(s) named. The material in it reflects our best judgement in light of the information available to CRA at the time of preparation. No portion of this report should be used as a separate entity, as it is written to be read in its entirety. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, is the responsibility of such third parties.

Section 6.0 References

